Design and Development of an Artificial Intelligence based Expert System for Science Students and Examine its Effect on Higher Order Thinking Skills and Creative Insight

A

Synopsis

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Introduction

In the era of science and technology the responsibility of educational institutions increases to bring out or develop such products in the form of students, who are not only equipped in Higher Order Thinking skills but also have Creative Insight to meet out the challenges of the life. Different educational policies have recommended the integration of Technology in Education such as- **National Curriculum Framework (NCF, 2005)**; chapter 5 focuses on Systemic Reforms with technological innovation in teaching learning is also necessary for learners with special needs, teacher training support, facilitated classroom learning. **National Research Council (NRC, 2007)** reported that the strength of the nation is resulting in huge part from the point of view of production of skilled persons and the stream of technical and scientific innovations they develop. **National Curriculum Framework for Teacher Education (NCFTE, 2009)** suggested that with rise in science, social trends, advancements in technology and growth in research is a notch of education. In Recent, **National Education Policy (NPE, 2020)** recommended that there is a need to design such systems (technology based) which can help in achieving the educational targets. Such disruptive technologies make teaching learning interesting. In the recent scenario, various types of traditional Expert systems have been introduced but still the learning level is not improved much as per expectation. A few Artificial Intelligence (A.I.) based Expert Systems have been developed to improve the intelligence. A.I. based Systems consists of Hardware+ Software+ Intelligence based on experiences.

According to Tan et al. (2016), these systems are developed in different forms – Fuzzy logic, Genetic Algorithm, Frame based Expert System, Rule based Expert System, Neural Network etc. Expert System is the best system for making learning easy and interesting in which knowledge is the back bone, (Chaturvedi & Prajapati, 2015) (Fig. 1).

About an Expert System

An Expert System is built for capturing the knowledge by interviewing, having discussions, interaction etc. with an expert, based on that the term Expert System is given to it. It is a type of computer program which is designed by the experiences of experts. It works in the form of asking questions and answering, (in the form of) explaining with logic and reasoning.

The base of an Expert system includes or is built with two components- Knowledge base and Inference Engine. The complete information and knowledge come under first component i.e. Knowledge base. The Inference engine focuses on how does system use reasoning through rules (based on IF-THEN). The expert's domain provides the knowledge to knowledge base in the form of may be simple facts or in the form of frame (Complex Representation). It also includes forward and backward chaining, where from the facts to conclusion forward moving is called as forward chaining and moving from hypothesis to known facts backward working is called backward chaining.

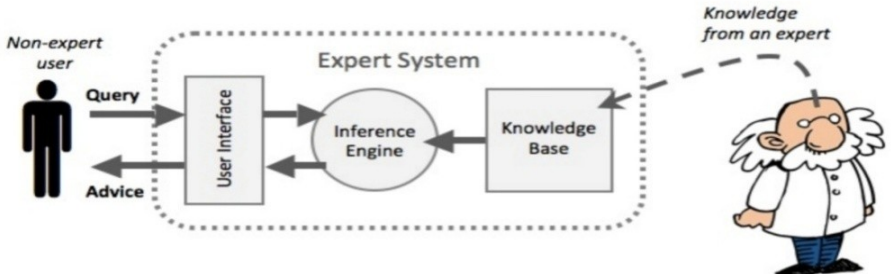

Fig. 1. Expert System Tan (2007) Cited by Tan (2016)

Artificial Intelligence (A.I.) Based Expert System

The cognitive functionality in an A.I. based systems is the demanding era of computing. In A.I. systems, Human-like-interaction is the present demand of the society creating scope in cognitive computers. An A.I. based Expert System deals and understands the user's queries, extracting the knowledge information through data sources which are diverse structured and unstructured, logical and reasoning related facts and selecting user's answer (responses), picking out the user's best response from applicable set of user's answers (Chandiok and Chaturvedi, 2018). An A.I. based Expert system is same as simple Expert System but the main difference is, in the knowledge base which modifies and responds according to individual's doubts (Fig. 2).

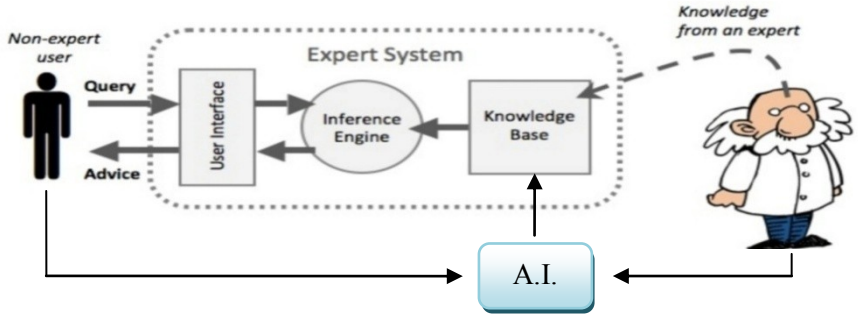

Fig. 2. Artificial Intelligence based Expert System

History of an Artificial Intelligence based Expert System

In the era of Machine learning, an A.I. plays an important role. It is based on the assumption that thinking of human being can be mechanized, which is possible in computer science that opens the light towards "Machine Intelligence or how a machine can react like a human". The early era faced a great difficulty to research in this field. In 1945 researchers introduce a mechanical system "Memex" (diskless device) holding capacity of huge number of books, pictures, and information. Then in 1950 concept of machine learning was introduced means how a machine behaves like a human? In 1952 the concept of Logical programming was introduced in machine learning by typical mathematical programming. Based on this a logical game was design – Games of checkers (checker game) which is simpler as compared to chess. This game focuses on techniques of learning and its rules were design by using the concept of machine learning. This learning technique was first developed by the Shannon (in the form of chess game). In a conference (1956) at the campus of Dartmouth College this amazing field of machine learning was introduced called Artificial Intelligence.

Fundamental Features of based Expert System

Knowledge Base- An A.I. based Expert system requires special approach to analyze the system for collection of data purpose. This knowledge acquisition or gathering process is highly difficult component. This process is called "knowledge acquisition bottle neck" (Ele et al., 2014). This Knowledge base system involves filtering knowledge from the person who is expert in the particular area and known as Domain Expert. This method involves a non interview and interview techniques.

Inference Engine- Human-computer-Inference is the attention point in this engine. Here Expert System typically assists with power of decision making and focuses on how a task is to be handled/performed in complex situation which the user prefers.

Development Stages of an Expert System

According to Turban (1998) cited by Ele et al., (2014) there are 6 phases of A.I. based Expert System; Initialization of Project, Analysis of System and design, Prototyping, Development of System, Implementation. Waterman (1986) cited by Ele et al., (2014) define 5 approach in development of an A.I. based Expert System these are- Identification, Conceptualization, Formulization, Implementation,

Testing. The learning abilities are also determined by an A.I. based Expert System in terms of Higher Order Thinking Skills and Creative Insight.

The word Higher Order Thinking Skills (HOTS) is based on Higher Order dimensions of Blooms's Taxonomy and further modified by Anderson. Schraw et al., (2011) cited by Kusuma et al., (2017) classifies bloom taxonomy into two types; Higher Order Thinking Skills and Lower Order Thinking skills. Application, Understanding and Knowledge come under Lower Order Thinking Skills while Analysis, Synthesis and Evaluation come under HOTS.

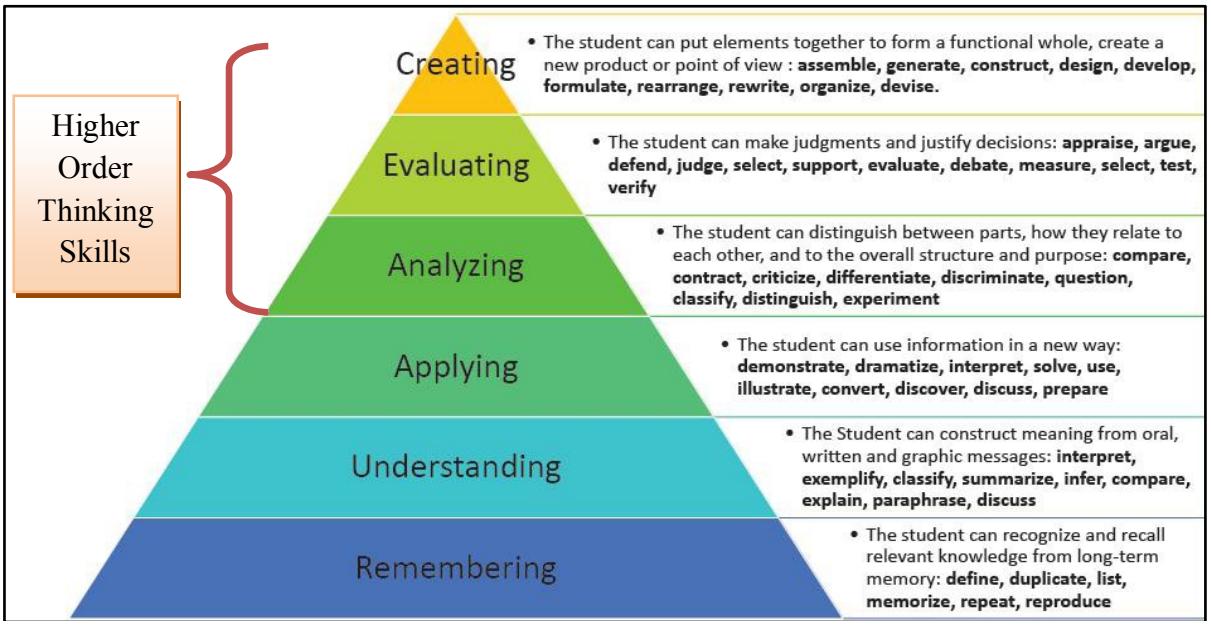
Higher Order Thinking Skills
Creating
• The student can put elements together to form a functional whole, create a new product or point of view : **assemble, generate, construct, design, develop, formulate, rearrange, rewrite, organize, devise.**
Evaluating
• The student can make judgments and justify decisions: **appraise, argue, defend, judge, select, support, evaluate, debate, measure, select, test, verify**
Analyzing
• The student can distinguish between parts, how they relate to each other, and to the overall structure and purpose: **compare, contract, criticize, differentiate, discriminate, question, classify, distinguish, experiment**
Applying
• The student can use information in a new way: **demonstrate, dramatize, interpret, solve, use, illustrate, convert, discover, discuss, prepare**
Understanding
• The Student can construct meaning from oral, written and graphic messages: **interpret, exemplify, classify, summarize, infer, compare, explain, paraphrase, discuss**
Remembering
• The student can recognize and recall relevant knowledge from long-term memory: **define, duplicate, list, memorize, repeat, reproduce**

Fig. 3. Higher Order Thinking Skills (HOTS) in Bloom's Taxonomy of Educational Objectives. Anderson andKrathwohl (2001) Cited by Abdullah (2018)

According to Krathwohl 2002, for developing critical thinking there are three indicators in HOTS which include analyzing, evaluating and creating. Thus, According to King (2002) as cited by Nachiappan et al., (2018) that Higher Order Thinking Skills is the highest level of thinking such as generating hypotheses, inferring, synthesizing ideas, drawing conclusions, analyzing and evaluating alternatives, comparing and differentiating which have been presented by a figure (Fig. 3).

Traditionally, Creative Insight has been considered as some unique thoughts and quick solutions. Creative Insight is also called as "Ah! Experience" and it appears when a solution to a problem immediately appears or flashes in mind. Basically, Insight is the essential part of creativity. It mainly focuses on positive affective feeling of something "making sense", "coming together" (Cosmelli and Preiss, 2014). The Gestalt movement has a great contribution toward the phenomena of

insight. Creative Insight is related with problem solving ability, which is unpredictable in nature (Sternberg and Davidson, 1995). Divergent insight or divergent thinking and problem solving ability are the two dimensions of Creative Insight. Bowden (2007) defines that the term Insight means deep and clear perception of situation, understanding feelings, understanding complex situations, clarity moment (Hedblom, 2013). Previous researches define that Creative Insight is the product of the mind (unconscious) piecing, experiences and forming original links among them. Thus, Insight is not a synonym of creativity; Insight can certainly results in solution during creative problem solving (Carpenter, 2019).

'Creative' is the highest level of Higher Order Thinking Skills which enables an individual to put different elements together to form a functional whole, create a new product or a new point of view. In this research, Creative Insight is taken separately as another variable which means creating meaningful connections, with intuitive thinking for creative execution, solving problem, finding solution etc.

Emergence and Justification of the Problem

Learning of 21st century is widely discussed among educational forum and conferences of educators. In most of the countries the main objective to this is to produce citizens for the next challenges of life. From this aspect it is very necessary to focus on the good learning situations (Balakrishnan et al., 2016). In the past years the learning process is fully controlled by teacher through Lecture method, Demonstration method etc. Then the trend shifted towards students centered method i.e. project method, Activity method, Heuristic method etc. In the present conditions the system of educational policies highly focuses on the integration of technology, which is the best learning approach. For studying the Science as a subject, the teacher develops new method of teaching by which high abilities of learning are developed in students. An A.I. based Expert System is one of the best system by which teacher or researcher can develop the interest of the students towards science subject. An A.I. based Expert System in education increases the student's motivation, interest and engagement level. To improve the student's reflective thinking and interaction abilities with others, focus is on visual skill enhancement and application of the value of technology in a real world conditions (Zirawaga, 2017).

An A.I. based Expert System balances the cognitive part and the functions of the brain which can control the range of learning disorders- dyslexia, dyscalculia etc. It also maintains mental peace of the learner by making learning interesting. An A.I. based Expert System will include educational games which may create and influence the "special" environment (Howard-Jones, 2011). Therefore, this study will describe the primary concept of an A.I. based Expert System, Creative Insight, Higher Order Thinking Skills, learning strategies fostering HOTS and Creative Insight. In the present study, the researcher will focus on the design and development of an A.I. based Expert System on Science, (a subject related with theories, facts, and discoveries) which includes Content, related Examples, Exercises, Activities and Brain Based Educational Games (puzzle, jigsaw, crossword jumble words etc, according to the demand of the content). An A.I. based Expert System will be designed and developed on the content material or instructional material to improve student's logic skills, reasoning skills, problem solving ability and divergent thinking. This type of creative thinking would also enhance the awareness towards the science curriculum and apply the knowledge gained through science in day to day life (Ramirez, 2008). To attract the individual toward science or scientific innovations, there is an urgent need to discover the values of reasoning, based on inquiry and to make student a creative problem solver. An A.I. based Expert System is the best example which supports the academic process with automated advising as much as like a human being (Al Ahmar, 2005; Al Ahmar, 2012).

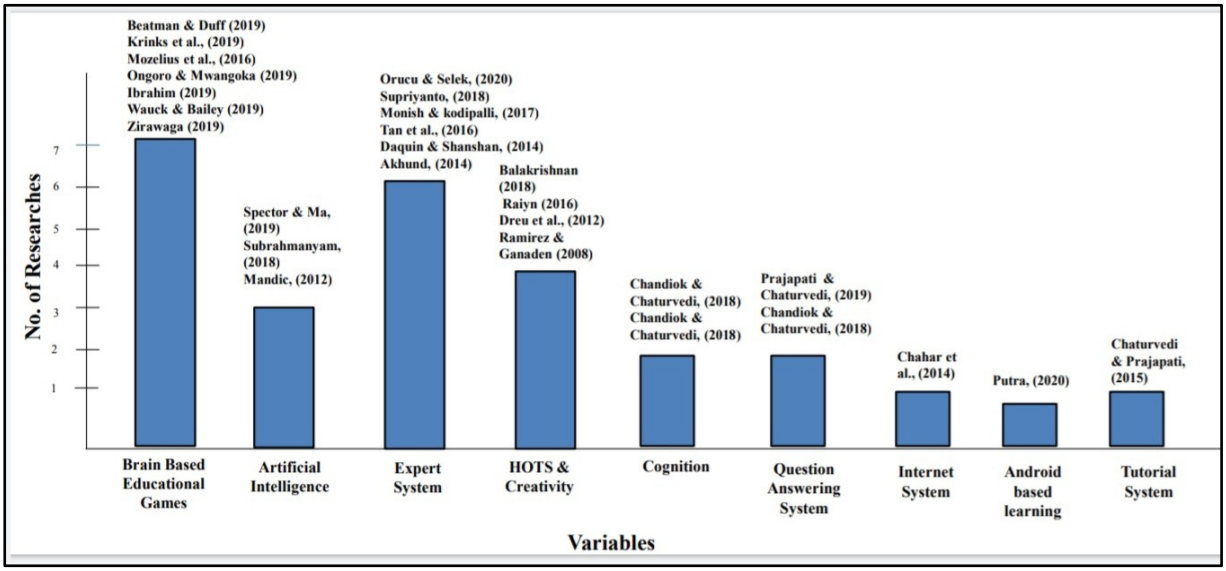

Fig. 4. Related Studies

To have more insight of this topic researcher has explored this area and found that this (An A.I. based Expert System) area is explored in foreign countries much and according to researcher's knowledge very less work is done in India as observed through literature review (Fig. 4). All the studies mentioned above are somehow related to Brain based Instructional Games, Artificial Intelligence, Expert system, Cognition, Question Asking system, Higher Order Thinking Skills and creativity, Android based system, Tutorial System, Internet system etc. It was found that the researches focusing on development of HOTS and Creative Insight with an A.I. are almost none and the role of an A.I. based Expert System on HOTS and Creative Insight is unexplored so researcher wants to do the experiments and explore this area in science subject. Researcher is also interested to satisfy her quires, such as:

- What is the level of HOTS and Creative Insight in Science subject students?
- Does an A. I. base Expert System affect on HOTS and Creative Insight in Science students?
- Does an A.I. base Expert System integrates along with traditional classroom teaching-learning process?

Statement of the problem

"**Design and Development of an Artificial Intelligence based Expert System for Science students and examine its Effect on Higher Order Thinking Skills and Creative Insight**".

An A.I. based Expert system includes set of rules based on a particular subject, Related Examples, Diagrams, Activities and Brain Based Educational Games on Science. This Expert System will be developed to study its effect on HOTS and Creative Insight of the students.

Definition of the terms

Artificial Intelligence Based Expert System

According to Chandiok & Chaturvedi (2018) "A.I. based Expert system (ES's) is an intelligent software tool which is used for acquiring knowledge from expert of a specific domain to offer assistance to its users over a dialog or a query talks conducted between the user and the ES application software".

Operational Definition- For the present study the term A.I. based Expert System will have the same meaning as discussed.

Higher Order Thinking Skills (HOTS)

According to Zohar and Barzilai (2015) "Higher Order Thinking Skills include critical, logical, reflective, metacognitive, and creative thinking. They are activated when individuals encounter unfamiliar problems, uncertainties, questions, or dilemmas. Successful applications of the skills result in explanations, decisions, performances, and products that are valid within the context of available knowledge and experience and that promote continuous growth in these and other intellectual skills".

Operational Definition- The HOTS is a skill of thinking that not only requires the ability to remember but also other superior abilities of mind contain the aptitude to Analyze, Synthesis and Create.

Creative Insight

According to Carpenter (2019) Creative Insight means "Creative Insight is about the ability to think, not just to recall, but to apply, suggest, extend and model, to create analogy".

Operational Definition- Creative Insight is creating meaningful connections, with intuitive thinking for creative execution.

Objectives

- To develop an A.I. based Expert System on Biology for class-IX.
- To study the effect of an A.I. based Expert System on HOTS of class-IX Science students.
    - To determine the effect of an A.I. based Expert System on Analytical skills
    - To identify the effect of an A.I. based Expert System on Evaluative Skills
    - To examine the effect of an A.I. based Expert System on Creative Skills
- To study the effect of an A.I. based Expert System on Creative Insight of class-IX Science stream students.

Hypotheses

$\mathbf{H_{o1}}$- There will be no significant effect of an Artificial Intelligence based Expert System on Higher Order Thinking Skills of Secondary level students.

H_{o2}- There will be no significant effect of an Artificial Intelligence based Expert System on Creative Insight of Secondary level students.

Variables of the study

- **Independent variable –** Artificial Intelligence based Expert System (On Biology)
- **Dependent variables–** HOTS **(**Higher Order Thinking Skills), Creative Insight.

Delimitations

The research will be delimited to –

- Agra city only.
- C.B.S.E. board only.
- IX class students of C.B.S.E. Board only.
- The Science stream students only.
- Biology Content of Science Stream only.

Methodology

Research Design

For accomplishment of the objectives of the present research **Development cum quasi experimental method** will be used, because quasi experimental studies do not require a true control group but they may include a comparison group (Rogers and Revesz, 2019).

Research Approach

In this, **Mix Method Research Approach** will be used to conduct the research which involves collecting, analyzing and integrating qualitative research (e.g. focus groups, interviews) and quantitative research (e.g. survey and experiment) approach of data collection.

Research Design

Nonequivalent Control Group Pretest-Posttest Design will be used. This is one of the type of quasi experimental design where dependent variable (DV) is measured in experimental group of individuals pretest (before) and posttest (after) then after an intervention (treatment), the same DV is also measured in pretest and posttest in another control group which is not treated with the same independent variable.

Table 1. Research Design

	Experimental Group (N=40)	Active Control Group (N=40)
Pre test	Check the level of HOTS and CI	Check the level of HOTS and CI
Intervention	A.I. based Expert System	e- Lesson Plan
Post test	Check the level of HOTS and CI	Check the level of HOTS and CI

Intervention

In this research the researcher will divide the sample units into experimental group and active control group (Au et al., 2020). Firstly researcher will apply the pretest on both the groups to compare the level of HOTS and Creative Insight in the sample. After comparing the scores of pretest, treatment will be applied on both the groups. Experimental group will be treated with an A.I. based expert system design on Biology and active control group will also be treated with e-lesson plans designed on Biology. Here the researcher will take the active control group because for better comparison in the results of both the groups.

Sampling Design/Strategy

The experimental group and active control group will consist of 80 students from a **Random Selection** of School. Researcher will use random selection because a sample (school) chosen randomly will mean to be an unbiased representation of the total population.

Sampling Procedure

The sample will be selected by using **Purposive Sampling technique**. In this research, researcher will choose purposive sampling because an Artificial Intelligence based Expert System will be designed and develop for Science students only. The researcher will select the sections of Science of class IX and sampling units (N) approx=80 to the accomplishment of the objectives. The researcher will take both the sections of class IX studying Science subjects for the research purpose (intervention or treatment). It has been surveyed and found by the researcher that there are almost two sections of Science subject in most of the CBSE schools.

Design and Developmental Phase- This phase will start with construction of an Artificial Intelligence based Expert System for science students, which will include the five phases of development-

a) **Knowledge Acquisition**– The process of getting the knowledge from experts (Human) or some other related sources (ex- online material, book, etc.). This phase will involve developing knowledge to resolve the individual's query/problem.

b) **Knowledge Representation**–This phase will used to code the knowledge for use by an Artificial Intelligence based Expert System. Knowledge Representation methods includes Frames, Cases and Rules. In this phase the knowledge will fixed into patterns or rules or cases. Here the researcher will use MATLAB (The language of technical computing) for coding the knowledge.

c) **Developmental Phase-** The developmental phase of an Artificial Intelligence based Expert System is the third phase which include the **Knowledge base** and **Inference Engine**.

In this Knowledge Acquisition and Knowledge Representation will develop the knowledge base (Rule base). In this rules are in the form of conditions and actions, means condition (IF) action (THEN). These rules can be heuristic, specific and chain together (ex- "IF A THEN B" "IF B THEN C" therefore A is greater than B which is greater than C so the conclusion will – "IF A THEN C". Here certainty factor represents that the confidence one has that a rule is valid or a fact is true.

Inference Engine part will help in decision making of an Artificial Intelligence based Expert System which will contain the ability of problem solving. Inference engine will analyze the query of the user and processes the rules. This will proceed the search portion of a rule based system.

d) **Evaluation Phase** – In this phase the developed Artificial Intelligence based Expert System will evaluated by the students. This phase will help in teaching and examine the science student's performance towards HOTS and Creative Insight.

e) **Refinement Phase –** Modification and refinement process in an Artificial Intelligence based Expert System will occur after evaluate the performance of science student's towards HOTS and Creative Insight, their feedback and also with the help of the expert's suggestions. In this, the knowledge base will modify and responses according to student's doubts this will comes under part of an Artificial Intelligence.

E-lesson Plans- In this research, researcher will construct the e-lesson plans of Biology for treating the active control group.

Research Tools- Following research tools will be employed for data analysis and interpretation-

- Higher Order Thinking Skills – The tool will constructed by the researcher based of three dimensions of HOTS analyzing, evaluating and creating.
- Creative Insight- The tool of Creative Insight will also constructed by the researcher on the basis of Problem solving ability which is the major dimension of Creative Insight (Carpenter, 2019).

Statistical Tools

Both the Descriptive and Inferential Statistics will be used. In this research,

- Descriptive statistics will be used for calculating Mean and Standard deviation, the main reason behind descriptive statistics is to provide a concise summary of the samples and the measures done on a particular study.
- NPC (Normal Probability Curve) will be used for testing of normality by Skewness and Kurtosis.
- Inferential statistics will be used for t-Test, to determine if there is a significant difference between the means of two groups, which may be related in certain features.

Research Methodology

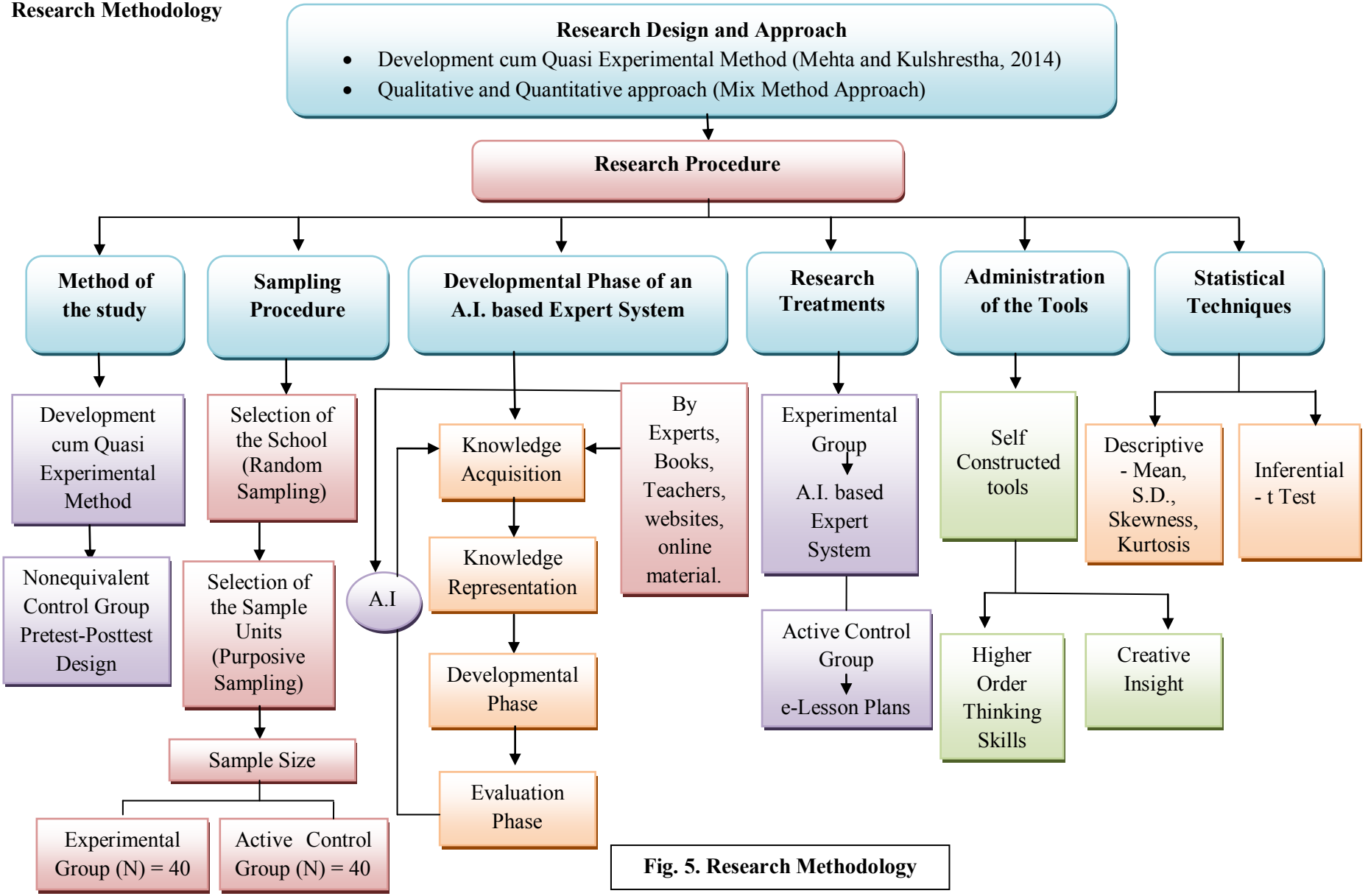

Fig. 5. Research Methodology

Educational Implications-

The educational implication can be observed here: An Artificial Intelligence based Expert System-

- It can be used as a support tool to develop learning experiences, by adaptation, interaction, critical thinking, problem solving ability and creative insight.
- Improved knowledge of the students in the particular subject will develop enthusiastic learners.
- It will engage and motivate the students and reduces monotonous learning.
- It will improve the students recall, remembering process and the students' use of suchknowledge in real life situations.
- It will be a form of fun-way learning for the students having disorder in maintaining attention for a longer time.
- It can overcome the problem related to incompetent and insufficient teachers' availability at different centers or schools.

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